STATEMENT OF WORK

For

COOPERATIVE RESEARCH AND DEVELOPMENT AGREEMENT

Between

The United States Environmental Protection Agency

National Exposure Research Laboratory

And

Water Gen, LTD

Title of Project: Evaluation of Atmospheric Water Generation Technology

Goal

The goal of this collaboration is to facilitate the potential use of atmospheric water generators (AWGs) in expanding the availability of water during shortages, contamination events and other interruptions of service. Specific objectives are to assess the quality of produced water and any potential health risks (Task 1) and to identify scenarios where AWGs may provide a viable water source (Task 2). This will ensure sustainable implementation of AWG in a manner protective of human health and in a cost-benefit way.

Approach

Task 1: Water Quality Analysis of AWG Condensate

Given the nature of AWGs, high quality produced water is anticipated. The primary health concern is opportunistic pathogens, such as *Legionella* spp. and *Mycobacterium* spp., that are commonly associated with drinking water infrastructure. Condensate and produced water samples will therefore be analyzed using cultivation-based and molecular methods (qPCR) to detect and quantify organisms of these species. In addition, next-generation sequencing (metagenomics) will be used to identify any additional risks and to compare the microbial community to that occurring in other water sources. Standard water quality parameters (*e.g.*, pH, conductivity, total dissolved solids, heterotrophic plate counts) will be monitored to ensure suitability of produced water for potable and non-potable applications.

Samples will either be collected by the Cooperator and shipped to the Laboratory for analysis (preferred), or collected from AWG test units to be installed at Laboratory facilities by the Cooperator. Weekly samples of both untreated condensate and produced water will be monitored for a period of three months (approximately 24 samples per AWG unit); however, a larger number of samples could be analyzed at additional cost. Samples will be taken from AWG units that have been in operation for a minimum of one month (or longer per Operator experience) to avoid potential start-up effects.

Laboratory Responsibilities: Provision of laboratory facilities; personnel; analytical equipment and reagents; and technical expertise.

Cooperator Responsibilities: Provision of AWG test units and/or water samples for analysis.

Task 2: Life Cycle Assessment of AWG Application Scenarios

To better understand the feasibility and marketability of AWG, the comparisons with other alternative innovative emerging technologies on a consistent economic basis will provide valuable quantified contrasts, predict most cost-effective solutions and offer more in-depth evaluations. Holistic approaches such as comparative life cycle assessment (LCA) and life cycle costing (LCC) provide tools to measure the trade-offs involved in various AWG scenarios and the opportunity to optimize cost benefits. A data inventory of various AWG systems will be developed to assess the life cycle costs and energy impacts for the AWG system used under different scenarios. Specific objectives for Task 2 are:

1) To develop data inventory and operating parameters of selected commercial AWG systems under various scenarios. The life cycle cost and energy analysis requires the consideration of capital investment (including the manufacturing and installation stages) and operating inputs (such as energy, chemicals, labor services and maintenance) for both the AWG system (Figure 1) and the treatment alternatives compared. In order to compare all alternatives on a consistent economic basis, the life cycle cost analysis considers the full-time capital and annual operating costs over the planning period to present the present worth/value. ORD's OpenLCA database provides the needed background unit processes for the complete analyses.

2) To create a broad comparative framework to assess innovative technology such as AWG and alternative options under different scenarios and provide understanding of the trade-offs involved and the opportunity to optimize cost benefits. Due to its uniqueness,

AWG systems have been proposed mainly as two categories of alternative water supply.

Various scenarios are proposed for evaluation:

Temporary/decentralization/mobile concept	Rationale 1	Rationale 2	Objectives
AWG vs Membrane Bioreactor (MBR)	As water resource becomes scarce and the financial burden of large piping and pumping infrastructure, decentralized concepts have been explored in urban settings.	During disaster relief efforts, the availability of clean drinking water is often critical, a mobile purification system for potable water would provide reliable temporary water supply.	To evaluate the life cycle costs and cumulative energy demand of the two technologies to achieve the same point of entry treatment
AWG vs bottled water	When emergency happens that water supply is not available, often bottled water is the option to provide potable water		To evaluate the life cycle costs and cumulative energy demand of the two options, take into account of the transportation and material inputs in bottled water
Permanent concept/alternative water source/superfund remediation sites			
AWG vs reverse osmosis (RO)	Desalinization has become increasing cost-effective, yet energy requirement may still be high. In the coastal region, more favorable conditions might		To evaluate the life cycle costs and cumulative energy demand of the two options, take into account of the waste disposal

	exist for the application of AWG		processes etc.
AWG vs contaminated source water (PCE dichlorination)	When superfund site involves remedial actions, the alternative water supply is often required. The treatment of contaminated source water is often not economically feasible		To evaluate the life cycle costs and cumulative energy demand of the two treatment trains, to achieve the same water quality

Laboratory Responsibilities: Provide the scenarios to be evaluated; background unit process database in OpenLCA database for the complete analyses: summarize the findings in peer review publications.

Cooperator Responsibilities: Provide comprehensive LCA and LCC analyses under different scenarios identified.

Task 3: Presentation of Results

Describe how and where results will be presented (e.g., at a workshop).

Laboratory Responsibilities:

Cooperator Responsibilities:

<u>Resources</u>

Laboratory
The Laboratory will contribute technical assistance, logistical support, and analysis of samples. This will include use of EPA facilities, supplies, equipment, and personnel.

Estimated total in-kind contributions (TBD)

Cooperator

The Cooperator will provide AWG units and/or samples for analysis at EPA facilities. The Cooperator may also contribute technical assistance and supporting research (including use of facilities, personnel and supplies), as needed.

Estimated total in-kind contributions $
Estimated total cash contribution (if any) $

Work Products

Product 1
Description
Product 1a (first element of Task 1 on Water Quality Analysis). EPA technical experts will review any data generated by the Cooperator regarding National Primary Drinking Water (NPDW) standard contaminants. EPA's experts will review data including finished water quality and the methods used to generate data for NPDW contaminants to assess the quality of the results. No testing by EPA necessary; technical review of

Timeline
Internal report delivered 3-4 weeks from the completion of the non-disclosure agreement and transfer of test data from the cooperator.

Use
General assessment of the acceptability of the water for drinking water under nominal operating conditions. Most useful for addressing suitability of the technology for shorter term applications (e.g., emergency response), depending on the scope of testing data provided.

Product 2
Description
Product 1b (second element of Task 1b Water Quality Analysis). Assessment of the growth of potentially harmful bacteria (e.g., *Legionella*, *Mycobacteria*) during longer term operation of AWGs, particularly intermittently and with storage of the water. Results dependent on testing of collaborator's technology performed by EPA-ORD.

Timeline
Internal report 4 months after completion of MTA and transfer of the equipment to EPA-ORD for testing. The expectations is for a peer-reviewed science report, including testing results from other AWGs, to be submitted within a year from initiation of testing.

Use
Define best management practices/guidance to minimize microbiologically related health risks associated with longer term use of AWGs. Assessment of chemical exposures from long term use of AWGs, particularly as a function of different sources of volatile compounds in source air, would require separate effort.

Product 3
Description
Product 2 (sole element of Task 2: Life Cycle Assessment of AWGs). Assessment of the life cycle costs of using AWG for producing drinking water compared to other approaches (e.g.,

bottled water) for scenarios of interest. Work does not require of the equipment by EPA, but rather transfer of verifiable data on the capital investment (manufacturing, installation) and operational (energy, chemicals, labor, maintenance) to EPA buy the vendor.

Timeline

Internal report 4 months after completion of NDA and transfer of the data to EPA-ORD. Work also requires definition of the EPA relevant alternative approaches for providing drinking water and scenarios of interest, including the scale and duration. The expectations is for a peer-reviewed science report, including testing results from other AWGs, to be submitted within a year from initiation of testing.

Use

Define the cost/benefits of AWGs vs other technologies to inform decision makers on selection of solutions for providing drinking water.